Physical losses in the rose supply chain: A Brazilian case study

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PHYSICAL LOSSES IN THE ROSE SUPPLY CHAIN:
A BRAZILIAN CASE STUDY

FIZIČKI GUBICI U LANCU SNABDEVANJA RUŽA:
BRAZILSKA STUDIJA SLUČAJA

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ABSTRACT

The purpose of this study is to measure the physical and economic losses in the rose supply chain of a case in Brazil. For the loss measurements, follow-ups were carried out in the distribution process with the main agents in the rose supply chain examined, recording the air temperature during transportation and the air storage temperature, as well as the durability and quality of roses delivered to the final consumer. To evaluate the key impact factor in the losses recorded, the probit model was used. Consequently, the refrigeration during transportation and the initial quality of roses (dependent on the farmer) were found to exert a significant effect on the quantitative and qualitative losses in the rose supply chain.
Key words: cutting flowers, post-harvest losses, cold chain.

REZIME

Ova studija ima za cilj merenje fizičkih i ekonomskih gubitaka u lancu snabdevanja ruže u jednom slučaju u Brazilu. Za merenje ovih gubitaka, u procesu distribucije su obavljeni praćeni postupci sa glavnim agensima koji su uključeni u ovaj lanac, evidentiraju temperaturu vazduha tokom transporta i skladištenja, kao i postojanost i kvalitet ruža na putu do krajnjeg potrošača. Da bi se utvrdio glavni faktor uticaja u ovim gubicima, korišćen je probit model. Na taj način je utvrđen značajan uticaj rashladnog procesa tokom transporta i početnog kvaliteta ruža, vezanih za farmera, na kvantitativne i kvalitativne gubitke.
Ključne reči: rezano cveće, posleubirajući gubici, rashladni lanac.

INTRODUCTION

Strongly influenced by immigrants, the flower and ornamental plant sectors in Brazil have developed over the years, gradually receiving increased attention. Nowadays, these sectors generate more than 2.5 billion dollars annually (based on the exchange rate of R$ 4.00/1 US$) and employ approximately 190,000 people (concentrated mostly in the São Paulo state, but found across the whole country) (*Neves and Pinto, 2015*).

Globally traded cutting flowers already constitute the largest group in the floriculture market. Furthermore, the geographical expansion of cutting flower production, culminating with logistical advances that facilitate the transport over long distances, should further facilitate the commercialization of cutting flowers (*Rabobank, 2015*).

An important feature of the flower and ornamental plant supply chain is a wide range of links, especially in the marketing and distribution sectors. Farmers, cooperatives, wholesalers and retailers are referred to as the main actors in this supply chain. With regard to perishable and value-added products such as flowers and fruits, all links in such a supply chain would benefit from an integrated system. According to *Milić et al. (2017)*, who analyzed the organic raspberry value chain under complex production conditions, changes in the business environment and large fluctuations in the demand exact the chain integration. Therefore, the optimal balance between producers and marketing should be struck in order to increase the interest of all parties in the chain integration process.

Transport, used throughout the distribution process, is of paramount importance to the integration of supply chain links. It also greatly affects the quality of products (*Neves and Pinto, 2015*). Provided transport is not organized and planned in a proper way, the logistics process precipitates physical losses (*Van der Vorst et al., 2012*).

Post-harvest handling losses pose one of the main difficulties faced by floriculturists. According to *Gurjão et al. (2006)*, such losses account for at least 30 % in Brazil. Cutting flowers are the most susceptible of all flowers to temperature variations and inadequate handling, incurring even larger post-harvest losses if not handled or stored properly.

An adequate transport system not only facilitates the reduction of transport costs from the farmer to the consumer, but also reduces the overall losses relative to all the agents involved (farmers, carriers and final consumers) (*Caixeta-Filho, 1996*). Accordingly, the purpose of this study is to measure the physical losses in the rose supply chain of a cooperative, as well as to reach possible solutions to the key hindrances in the logistics processes.

MATERIAL AND METHOD

This study, following a number of studies conducted by the Group for Research and Extension in Agroindustrial Logistics (ESALQ-LOG), is intrinsically a descriptive/exploratory study. Although there are several studies dealing with the rose supply chain, measurements of the quantitative and qualitative losses occurring in the flower distribution system can contribute to defining the most important indicators of the system's efficiency and effectiveness, as it was already emphasized by *Arnaldi and Perosa (2005)*.

For the data collection, encompassing a detailed survey of the losses recorded, follow-ups were carried out during loading operations on two rose farms, and also during unloading operations in the distribution process. The routes selected as representative of the rose distribution flows are illustrated in Figure 1, namely Route 1 (from Andradas (MG) to Holambra (SP)) and Route 2 (from Holambra (SP) to a supermarket in Piracicaba (SP)).
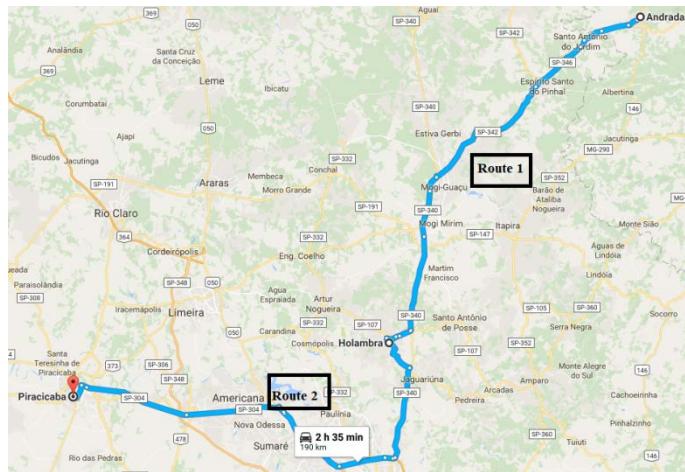

Fig. 1. Map of the routes analyzed

Relative to Route 1, a total of two different types of delivery were examined: a farmer's private truck and a shipping carrier (which collects load on several properties in Andradas (MG). A box containing two packs of roses (20 rose stems in total), grown by different farmers, was loaded into each truck every week. The boxes were unloaded at the Piracicaba´s supermarket and the rose samples were delivered to the final consumer after the analysis of qualitative losses and shelf life. This experiment was carried out over a period of three consecutive weeks.

To evaluate the effect of air temperature variations inside the truck during transport on the quality of flowers, data loggers were used to monitor the temperature of the load, which was recorded along the route every ten minutes during transport and storage at the cooperative. The quantitative and qualitative losses in roses were recorded upon the arrival of the truck to the supermarket and during the shelf life of roses. The parameters under consideration involved the physical losses of roses in the first three days and the number of vase life days. Fig. *2* shows two rose stems analyzed (which also exhibited the loss of quality due to petal yellowing).
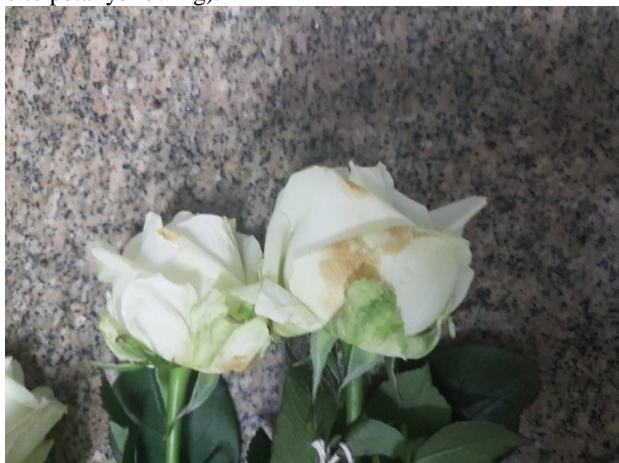
Fig. 2. Loss of rose quality observed in the first three days

A descriptive analysis of the data obtained was initially performed, including the types of transport and the temperature values obtained in the experimental period of three consecutive weeks. Subsequently, estimates of the rose quantitative and qualitative losses were made using the probit model, i.e. a binary response model used to estimate the probability of an event depending on the exogenous variables.

The probit model

The probit regression is argued by *Stock and Watson (2004)* as a nonlinear model for binary dependent variables. The cumulative distribution function (CDF) is used in such models with a probability between zero and one. The probit regression uses the CDF of the standard normal distribution.

The population probit model with multiple regressors is expressed as follows:

$$P(Y = 1)|X_1 X_2, \dots X_k,) = \emptyset(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k), \quad (1)$$

where the variable Y is binary, $\emptyset$ is the standard normal cumulative distribution function, X_1, X_2, etc. are the regressors, and β_0, β_1, etc. are the probit coefficients.

With computer programs such as Stata® (the statistics package used in this research), *Wooldridge (2006)* emphasizes that the main difficulty of the probit model is associated with the presentation and interpretation of results.

Therefore, the coefficient values obtained show partial effects of each X_k on the response probability value, as the statistical significance of X_k is determined by rejecting H_o: $\beta_k = 0$ at a low significance level.

Finally, an analysis of the marginal effects obtained by estimating the probit, as given by Equation 2, allows interpreting the results in a quantitative way, i.e. measured in probability units.

$$\frac{\partial P(Y=1|X)}{\partial Xk} = \beta k f(x\beta) \quad (2)$$

being f(.) = $\partial F(.)/\partial x$.

The empirical model

The dependent variable in the present empirical model is a result of the physical losses in roses, which may or may not occur. This variable assumes the value 1 provided the losses are recorded, whereas otherwise the value is 0.

After the primary data collection, the following variables, related to two farmers, were analyzed: the average temperature recorded in each truck on Route 1 (Andradas (MG) – Holambra (SP)) and Route 2 (Holambra (SP) – Piracicaba (SP)), and the type of transport (the farmer's private transport or a shipping company).

To demonstrate the influence of variables on the loss probability, Equation 3 is expressed as follows:

$$P(Y = 1)|X_1, X_2, X_3, X_4) = \emptyset(\beta_0 + \beta_p X_{1p} + \beta_2 X_2 + \beta_3 X_3 + \beta_t X_{4t}), \quad (3)$$

where Y corresponds to the binary variable (Y = 1 indicating losses in roses and Y = 0 indicating a lack of losses or the "no losses" in roses), $\beta_0, \beta_p, \beta_2, \beta_3, \beta_t$ are the parameters to be estimated by the probit model, *t* corresponds to the type of transport (t = 1 is the farmer's private truck and t = 2 is the contracted carrier), *p* corresponds to the producer of roses (p = 1 is Farmer 1 and p = 2 is Farmer 2), X_{1p} refers to the binary variable PRODUCER (corresponding to the *p-th* farmer: if the rose is produced by Farmer 1 (p = 1), the variable assumes the value 1, and if the rose is produced by Farmer 2 (p = 2), the variable assumes the

value 0), X_2 refers to the continuous variable T1 (which accounts for the average air temperature in ^{o}C inside the truck on Route 1 (farmer-cooperative), X_3 refers to the continuous variable T2(which accounts for the average air temperature in ^{o}C inside the truck on Route 2 (cooperative-supermarket), and X_{1t} refers to the binary variable TRANSPORT (corresponding to the *t-th* transport: if the farmer's private truck is uded (t = 1), the variable assumes the value 0, and if the contracted carrier is uded (t = 2), the variable assumes the value 1).

RESULTS AND DISCUSSION

Results of the probit model

The probit model based on the experimental data collected indicates a high percentage of hits, approximating to 82 %. Table 1 presents the probit model results, as well as their marginal coefficients. The coefficients of the variables PRODUCER, T1 and T2 are statistically significant at a level of 1 %. Although the coefficient of the variable TRANSPORT is significant only at a level of 10 %, the model including such a variable is more robust.

Table 1. Results of the probit model and marginal coefficients

Variables	Coef.	Estat. Z	P > |Z| P-value	Marginal effect (dF/dx)
Constant	-8.95	-5.03*	0.000	-
PRODUCER	0.59	3.01*	0.003	0.16
T1	0.26	2.70*	0.007	0.07
T2	0.44	5.10*	0.000	0.12
TRANSPORT	-4.15	-1.44**	0.149	-0.11
Observations				240
Chi-Squared Statistic				41.44*

*Significance level of 1 % **Significance level exceeding 10 %

The marginal coefficients estimated using the probit model, with dependent variables representing the probability of losses in roses, indicate that the roses produced and delivered by the farmer exhibit an increase of 16 % in the probability of physical losses. The marginal effect should be interpreted as a change in the probability of losses at an infinitesimal change in each independent variable and a discrete change in the binary variables.

The air temperature variability observed indicates that the temperature increase recorded on Route 2 (T2) is more adverse with regard to losses in roses than that recorded on Route 1 (T1). An increase of 1 ℃ in the average air temperature precipitates a probability of an additional 12 % loss. In like fashion, an increase of 1 ℃ in the average temperature on Route 1 (T1) increases the probability of loss by 7 %. As the data collection in this study was limited to a total of only 2 journeys, it was not possible to include the distance transported as a variable. However, the distance transported is regarded as an important constituent of the process and should be considered in future studies, as an increase in the average air temperature over longer distances can lead to an increased probability of losses in roses. The model results obtained were used to estimate the probability of losses at specific points in the rose supply chain. Therefore, the probability of losses in the case of Farmer 1 is close to zero when the average temperature of T1 and T2 is 6 ℃. When the rose supply chain is observed at 12 ℃ during transport, i.e. the average temperature throughout the entire journey, relative to

Farmer 1 and 2, a difference of 20 % was recorded in the quality of roses delivered (Farmer 2 delivered roses of superior quality). Nevertheless, the probability of losses in the case of both farmers was too high.

The sensitivity analysis of an increase in the probability of rose losses is shown in Figure 3. The probability of rose losses due to an increase in the temperature T1 was analyzed, with T2 remaining constant at 6 ℃, followed by analyzing the probability of losses when T2 was increased and T1 kept at 6 ℃. A greater sensitivity of roses was recorded in the final transportation route, probably because the roses were in an advanced maturation stage.
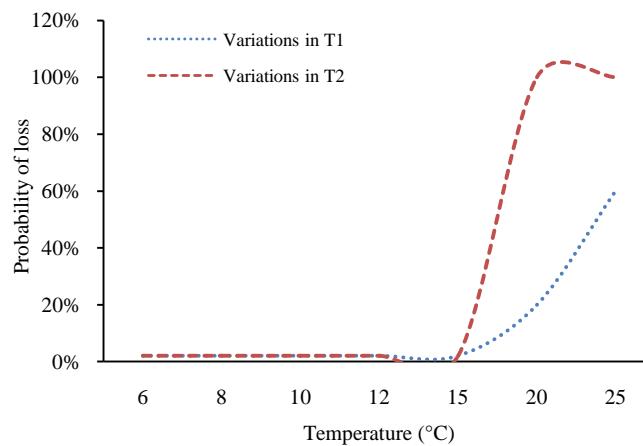

Fig. 3. Sensitivity analysis of the probability of rose losses at different air temperatures

The low average T1 temperature and the high T2 temperature exerted an adverse effect on the roses of Farmer 2 (considered to be of superior quality) and rendered futile all the measures undertaken by the farmer to preserve the quality of roses such as using private trucks and an on-farm cold storage.

Follow-up results

The follow-ups to rose loading and transportation between the farmers and cooperative and the cooperative and retail outlet underscored the relationship between these activities and the losses recorded in roses. The temperatures analyzed during transport over three weeks of the experiment were labelled T1 (the average temperature on Route 1) and T2 (the average temperature on Route 2). The S1 and S2 roses analyzed were related to the roses produced by Farmer 1 and Farmer 2, i.e. the S1 roses were delivered to the cooperative by an outsourced carrier and the S2 roses were delivered to the cooperative by the farmer´s private truck. The T1 temperature recorded for the S2 roses was lower, averaging 7.37 ℃. Conversely, the average temperature of the S1 roses aproximated to 10 ℃. Therefore, the use of the farmer's private truck was found to exert a positive effect on the quality of rose transport and the maintanance of the cold chain.

With regard to the outsourced shipping carrier, an important issue observed is the partial load (LTL) shipment that combines shipments from multiple customers. The LTL shipments often make several stops on different farms to load roses, and thus cause temperature variations leading to elevated temperatures inside the truck. Furthermore, the average T2 temperature recorded (related to a rose cold storage at the cooperative and the transport to the retail outlet) was the highest of all in the follow-ups conducted (it is important to highlight that this transport was also outsourced).

As far as the total losses in rose stems are concerned, the loss of rose stems in the case of Farmer 1 (P1) was 17 % higher than in the case of Farmer 2 (P2). The total losses when the transport was outsourced (S1) and done by the farmer´s private truck (S2) were 24 % and 21 %, respectively (of a total of 120 stems produced and delivered by each farmer). The T2 temperature function shows that the total losses in the roses analyzed increased over the experimental weeks as well as the average T2 temperature.
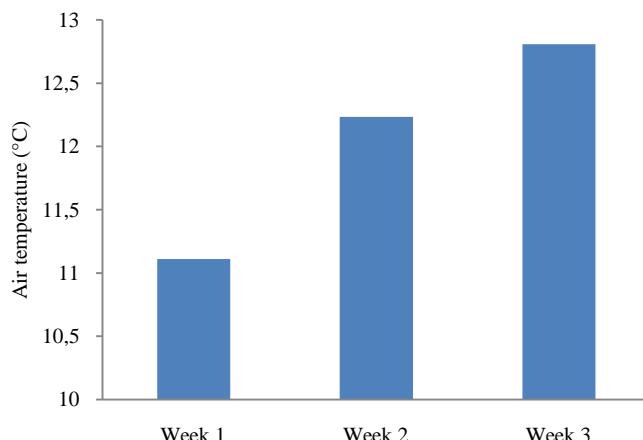

Fig. 4. Total losses recorded over the experimental weeks compared to the average air temperature inside the truck during transport

Yellowing of the roses was found to be prevalent, caused by the emergence of the fungus *Botrytis cinerea*. However, only 5 % of these losses were incurred by mechanical damage, i.e. stem fracture and rosebud kneading. The average vase life of the S1 roses was shorter than the average vase life of the S2 roses. Therefore, private transportation, accompanied by lower average air temperatures, positively contributes to the durability of roses, as shown in Table 2.

Table 2. Average vase life (in days) over the experimental weeks

	P1	P2	Average vase life
S1	2.75	4.45	3.6
S2	5.65	5.15	5.4
Average vase life	4.2	4.8	

CONCLUSION

Owing to the integration needed between a large number of existing and active links in the Brazilian rose market and supply chain, transportation has been found to be of crucial importance to preserving rose quality and minimizing rose losses. In the present study, the physical losses in the roses originating from Farm 1 amounted to 24 %, whereas the physical losses in the roses from Farm 2 were 21 % (mostly due to rose yellowing caused by the emergence of diseases).

The marginal coefficients obtained in the probit model estimates indicate that the roses of poorer quality produced and delivered by Farmer 1 exhibited a 16 % increase in the loss probability (implying the importance of continuous cultivation improvement and on-site post-harvest management).

Although restricted to a small number of samples and variables, the probit model provided a sound and interesting tool for evaluating the losses in rose transport. In addition to the distance transported, other factors such as transportation routes, rose varieties and packaging greatly affected the model results. However, the marginal coefficients obtained for the average temperatures calculated indicate that an increase of 1 ℃ on Route 1 and 2 increased the probability of losses by 12 % and 7 %, respectively. Under the conditions considered in the present study, the cold chain, suitable packages and a short travel time were found to be crucial to rose transportation. Therefore, it is necessary to strive after the reduction of information asymmetry, enabling the adoption of good practices in the whole distribution process. In this regard, the coefficients obtained by the probit model demonstrate that if any of the rose transportation phases are not carried out abiding by the stipulated standards, the entire process will be adversely affected.

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